# The Petrology and Geochemistry of the Civrari-Southern Lanzo Ophiolite, Piemonte, Western Italian Alps

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## Abstract

Alpine-Apennine ophiolites have been found to represent subcontinental lithosphere emplaced at ocean-continent transition zones during lithospheric thinning and exhumation during the opening of the Alpine Tethys in Jurassic times. Preserved mantle rocks have provided insight into mantle dynamics occurring at different depths, from melt-rock reaction and asthenospherization to melt intrusion. The Zermatt-Saas ophiolites on the other hand give us more insight into slow-spreading events caracterising the slow-spreading Alpine Tethys, with well preserved former slices of oceanic crust, and only locally preserved lenses of peridotites. The presence of a small outcrop of peridotites within a sliver of slow-spreading oceanic crust, represented by the Civrari Ophiolite, has given us the ability to study peridotites and magmatism in a more oceanward environment. The Civrari peridotite consists of a small lense of both refractory and reactive harzburgites intruded by late stage low pressure olivine-gabbros. The ultramafic massif in itself is strongly homogeneous and of refractory nature, with strongly contrasting compositions when compared to subcontinental mantle exhumed throughout the Alps. A detailed study suggests that the Civrari peridotite originated from a deeper part than the Lanzo peridotites, with preserved high temperatures suggesting a rapid exhumation to the ocean floor, without any prior accretion to the subcontinental lithosphere. Harzburgites were formed through ~13% partial melting, beginning in the stability field of garnet, before reaching the spinel stability field. Localised percolation of small melt increments (very low melt/rock ratio) in the stability field of spinel caused some areas of the Civrari peridotite to become reactive harzburgites (dissolution of orthopyroxene, precipitation of ol + spl + cpx), before localised melt impregnation at shallower lithospheric levels dissolved clinopyroxene to form orthopyroxene + plagioclase.
Preserved reacted clinopyroxene show trends of LREE enrichement and $TiO_2$ and $Na_2O$ enrichement, with core to border zonations. Impregnation of lithospheric peridotites by orthopyroxene-saturated melts is consistent with migrating melts

cooling and crystallizing during the exhumation of the peridotite. MORB-type aggregated magmas between the Civrari and Southern Lanzo domains occurred around 150 Ma and originated from a similar MORBtype depleted asthenospheric source. Increase in partial melting by the Civrari Ophiolite, coupled with the high temperatures recorded in peridotites, and the limited melt-interaction suggests that the Civrari ophiolite is found in a more oceanward environment than the Southern Lanzo peridotite, and might represent Jurassic-age oceanic crust.

Upon Jurassic exhumation, sea-floor exposure caused intense serpentinisation of both the Southern Lanzo and the Civrari ophiolites, as is attested by the $^{87}Sr$, radiogenic Pb, of mafic rocks, $\delta O^{18}$ and $\delta D$ values of ultramafic rocks as well as LREE enrichment of serpentinites as one gets closer to the sedimentary cover. Furthermore, intense oceanwater-rock interaction is attested by the presence of rodingites, chlorite-magnetite- and chlorite-schists, sedimentary ophicarbonates as well as the compositional variations of mobile elements in mafic rocks. Furthermore, the composition and mineralogy of mafic rocks influences how well both HP mineralogy and ocean-alteration signature are preserved, with more Mg-rich samples showing stronger greenschist retrograde mineralogy and a stronger ocean-water interaction signature. Peak high pressure eclogitic metamorphism was not preserved in the Civrari oceanic sedimentary cover, where calculated values reached 1 Gpa, and 450-500°C. Detailed mapping of the Civrari-Southern Lanzo area and whole rock geochemistry of serpentinites within the sedimentary cover suggests that the Southern Lanzo area consists of a sedimentary cover and is prolonged farther West than was previously thought.